Space Weather Technical Forecast

Issued on Sunday, 09 June 2024 at 12:13 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: S1 at first on day 1 (09 June), gradually reducing. G2 Likely on day 2 (10 June). R1/R2 Likely, risk easing into new UTC week.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Activity has been Moderate at GOES16/18 during the last 24 hours, with occasional weak M-class flares, peaking with an M1.6 from AR3697 at 09/0701UTC.
There are currently up to eleven sunspot regions on the disc. AR3709 (Cki/Beta-Gamma) has shown further development in its main lead portion and has a moderate magnetic complexity. The most active region on the disc is AR3697 (Dkc/Beta-Gamma-Delta) in the southwest, with this group being difficult to analyse as it approaches the western limb but appears to have reduced a little in size. Other regions are smaller, magnetically simpler and either showing slight decay or little change in development.
No new CMEs were noted in the period.

Solar Wind / Geomagnetic Activity: Solar winds, as observed by ACE at L1, showed some weak coronal hole influence for much of the 24-hour period. Solar winds were predominantly slightly elevated, with occasional peaks into elevated levels, peak speed around 540km/s. The density was below average. The IMF (Interplanetary Magnetic Field) was at weak levels 3 to 7nT. The north-south component varying between -5nT and +5nT. The phi angle was largely positive (away from the Sun) until 08/2359UTC, after which it fluctuated between positive (away from the Sun) and negative (toward the Sun).
The net result of the above solar wind measures was for Quiet (Kp 1 to 2) geomagnetic conditions with one Unsettled (Kp3) interval early in the period.

Energetic Particles / Solar Radiation: High energy (greater than 10 MeV) proton flux observed by GOES18 has gradually eased from Moderate (S2) solar radiation levels to Minor (S1) radiation levels. 100MeV protons also showing a slow downward trend.

High energy electron flux (greater than 2MeV) observed by GOES16 was at predominantly Normal Background levels, with the associated 24-hour fluence well below Active. Observed fluence at 08/0300UTC was 1.49e6 integrated pfu (more recent observations currently unavailable, which will be investigated).

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Four-Day Space Weather Forecast Summary

Solar Activity: Further M-class flares are Likely, with an ongoing Slight Chance of an X-class flare - these most probably from AR3697 or AR3709. The probabilities of both fall slightly by the very end of the four days as a result of the passing from the visible disc of AR3697.

Solar Wind / Geomagnetic Activity: The CME associated with the 08/0149 UTC M9.7 flare shows an asymmetric halo in its shock, and there is a risk of G2 Moderate geomagnetic storm conditions on day 2 (10 June). This is the only CME currently in the forecast.

Background to Slightly elevated solar winds are expected on day 1 (09 June) from modest coronal hole fast wind influence. On day 2 (10 June) solar winds are likely to become elevated, perhaps strong (around 600km/s), with the anticipated CME arrival. Winds will then gradually subside through days 3 and 4 (11 and 12 June).

Geomagnetic activity is expected to be Quiet to Unsettled on day 1 (09 June). The arrival of 08 June CME is expected during the UTC morning of day 2 (10 June), with G2/Moderate geomagnetic storm conditions likely to develop for a time. Elevated geomagnetic activity may linger into the start of day 3 (11 June), before gradually waning to mainly Quiet by the end of the four-day period.

Energetic Particles / Solar Radiation: High energy proton flux should now show a gradual waning tendency following its S3 peak, although proximity to this level means that any further suitable events from AR3697 may see levels rise once again. S1 is therefore Expected at first, falling to background levels late on day 1 or early day 2 (9/10 June). The risk should fall further to mirror the raw value for the sunspot regions on the disc from day 3 (11 June).
High energy electron flux is forecast to persist at predominantly Normal Background levels, and the associated 24-hour fluence forecast should remain below the Active threshold. There is a Slight Chance of recovery by the final day of the period, in the wake of any CH42 and/or CME influence.

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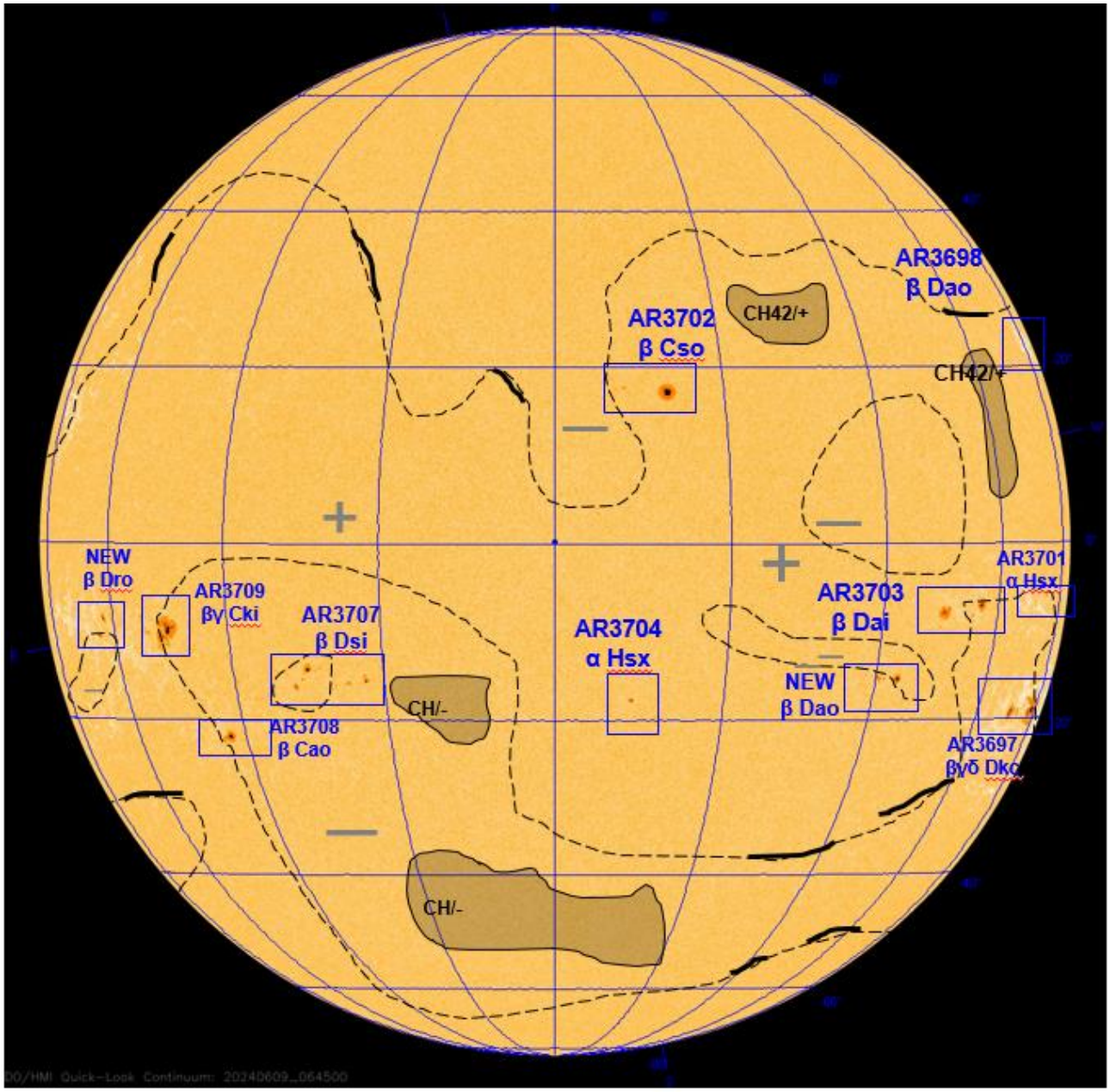
Figure 1. Solar Analysis Valid 09/0700 UTC.



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Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

The M9.7 flare from AR3697 at 08/0149UTC in the southwestern disc generated a Coronal Mass Ejection (CME). A substantial coronal dimming and EUV wave were also seen, with the latter crossing the solar meridian in the minutes following the flare. Also observed were a 10cm radio burst, Type IV and Type II radio signatures, with the last of these giving an estimated CME speed of 894km/s. The ejecta show a (possibly double-lobed) asymmetric halo on coronagraphs. MOSWOC Enlil modelling suggests a likely arrival time at Earth in the UTC morning of day 2 (10 June). Most of the ejecta appears directed south and west of the Sun-Earth line, but there may be up to two shocks that appear to impinge on the Sun-Earth line, and a glancing blow of some description is therefore expected. No other new CMEs were noted in the period.

Solar winds have been predominantly slightly elevated, with occasional peaks into elevated levels, peak speed around 540km/s. This enhancement is likely from the elongated and rather narrow CH42/+ in the northwest disc, this is now waning as solar wind speeds decline back towards background levels. On day 2 (10 June) solar winds are likely to become elevated, perhaps strong (around 600km/s), with the anticipated CME arrival. Winds will then gradually subside through days 3 and 4 (11 and 12 June).

Geomagnetic activity is expected to be Quiet to Unsettled on day 1 (09 June). The arrival of 08 June CME is expected during the UTC morning of day 2 (10 June), with G2/Moderate geomagnetic storm conditions likely to develop for a time. Elevated geomagnetic activity may linger into the start of day 3 (11 June), before gradually waning to mainly Quiet by the end of the four-day period.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	5	70	30	1
Strong	G3	No	1	10	5	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
08/0439	Partial	AR3697	SW	1154km/s	10/0600UTC	Mainly shock, but large event. Arrival error bars probably contained wholly within UTC morning of 10 June

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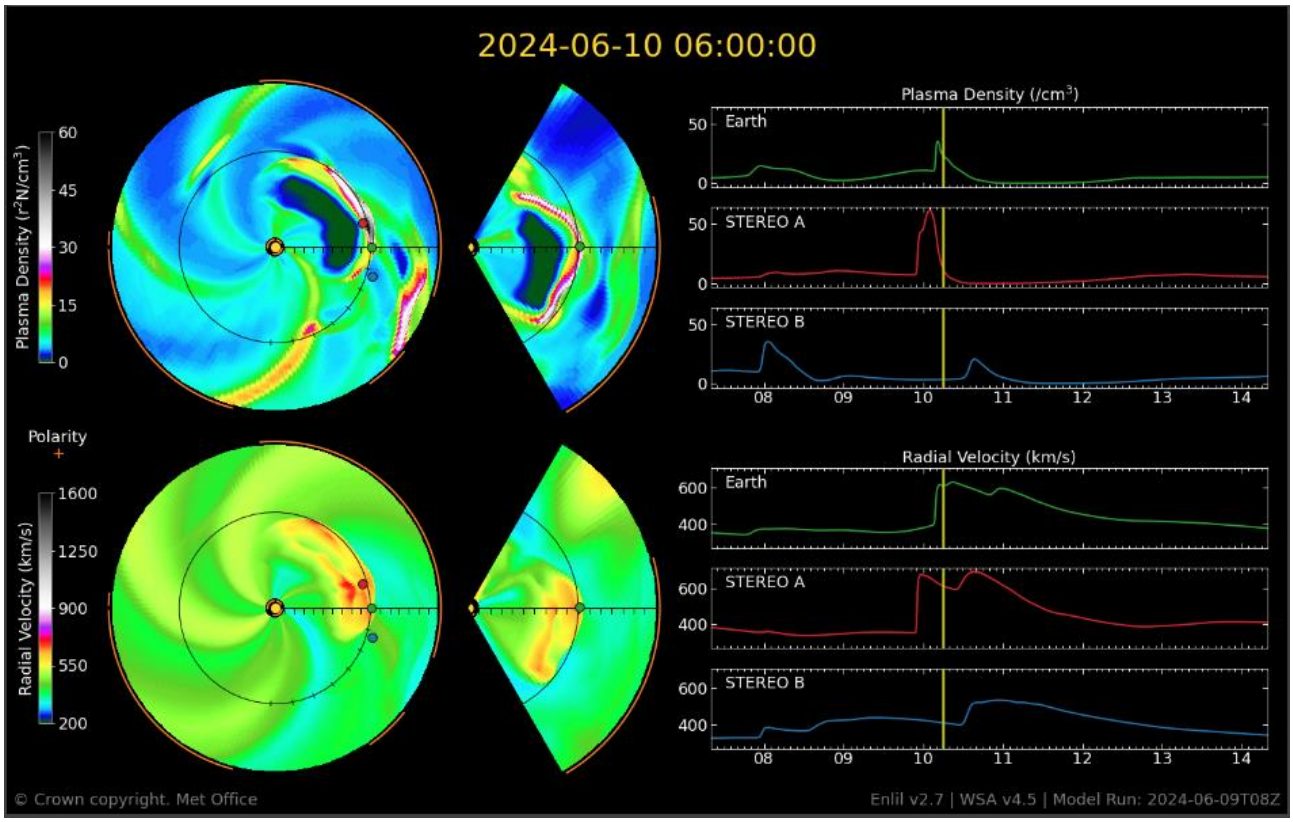
Figure 2: Enlil shows CME arrival around 10/0600UTC



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Radio Blackouts - X-Ray Flares:

Solar activity has been Moderate during the last 24 hours, with a couple of weak M-flares from AR3709 in the southeast, and AR3697 in the southwest.
Further M-class flares are Likely, along with a Slight Chance of an X-class flare, these most probably from AR3697 or AR3709. AR3697 should depart the Earth-facing disc by day 3 (Tuesday 11 June), leading to an overall slight drop in daily risks, with far-side soundings not suggesting any further substantial arrivals in the period.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	70	70	60	60
Very Active	R3 to R5 X Class	No	15	15	10	10

Solar Radiation Storms - (High Energy Protons):

AR3697 is currently in a prime position to deliver further S-scale enhancements should it flare suitably. Given the enhanced levels of greater than 10MeV protons in the interplanetary medium, this means further exceedance of S3 is now rated at a Slight Chance, with this risk falling the more time that elapses between proton-rich flares. S1 is therefore Expected at first, with a Slight Chance of S2, falling to background levels early on day 2 (10 June). The risk should fall further to mirror the raw value for the sunspot regions on the disc from Tuesday 11 June.
Greater than 100MeV protons should show a similar relaxing trend following its 8pfu peak on the UTC morning of 08 June, probably fully relaxing to resting background in around 24 hours time - again, barring new events.

Radiation Storms	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ S1	Yes	100	40	20	10
Very Active	≥ S3 *	No	5	5	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

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High Energy Electrons Event (≥ 2MeV):
The high energy electron flux is expected to persist at Normal Background levels for much of this period - now rendered more likely by the anticipated inbound 08 June CME. CH42/+ influence during day 1 (09 June) now in all likelihood forms a minor component of the forecast, with any eventual reaction upwards now delayed until the final UTC day of the period, and even here only rated at a Slight Chance.
MOSWOC REFM output is viewed as limited for good guidance, although it maintains fluence below or well below the Active level as is anticipated. However, it cannot account for the incoming CME and its range is not sufficient to hint at any potential rise in the T+72-96 hour period.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^{8}$**	No	1	1	5	10
Very Active	**≥ 2 MeV ≥ $1x10^{9}$**	No	1	1	1	1

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